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1 DEVICE AND METHOD FOR COMPENSATING NON-UNIFORMITIES IN
2 IMAGING SYSTEMS

Description

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6 The invention concerns an exposure and modulation device for modulating the
7 exposure intensity in the integrating digital screen imaging system (IDSi)
8 comprising a light source and a light modulator that has a plurality of rows of
9 light-modulating cells, and comprising a device for imaging on the light
10 modulator, a device for imaging the light modulator onto photosensitive material,
11 and a device for producing a relative motion between the light modulator and the
12 photosensitive material, whereby the direction of motion is basically
13 perpendicular to the direction of the rows of light-modulating cells, and
14 comprising a device for scrolling a data pattern through the various columns of
15 the light modulator at a speed by means of which the imaging of any data pattern
16 is kept basically stationary relative to the photosensitive material during the
17 motion.

18
19 The invention further concerns a method for exposing and modulating the
20 exposure intensity in the integrating digital screen imaging system (IDSi), in
21 which light from a light source is imaged on a light modulator that comprises a
22 plurality of rows of light-modulating cells, and is modulated by this, after which
23 the light modulator is imaged onto photosensitive material moving in a motion
24 relative to the light modulator, whereby the direction of motion is basically
25 perpendicular to the direction of the rows of light-modulating cells, and that the
26 data to be imaged on the photosensitive material are scrolled through the
27 columns of the light modulator at a speed by means of which the imaging of any
28 data pattern is kept basically stationary relative to the photosensitive material
29 during the motion.

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1 The device described hereinabove was made known in DE 41 21 509 A1. The
2 invention described in this document is particularly significant for processes in
3 which large quantities of modulated light are required in the blue and ultraviolet
4 range, such as in the exposure of printing plates, the exposure of printed circuits,
5 and in stereolithography. According to the principle of the invention, the
6 photosensitive material is moved continuously while the image contents are
7 scrolled in the opposite direction at the same speed by the light modulator. The
8 image contents therefore remain in one location on the material to be exposed.
9 The exposure takes place by integrating all short, individual exposures of the
10 cells in a row. Strips having a width corresponding to the number of rows of the
11 light modulator are therefore exposed. A larger area is exposed by placing a
12 plurality of strips next to each other.

13
14 The problem with the device described is that non-uniformities in the light
15 modulator, e.g., caused by differences in illumination or imaging power differing
16 at the local level when cells are controlled in uniform fashion, produce different
17 exposure results within a partial image on the material to be exposed. As a rule,
18 the differences between adjacent pixels on the photosensitive material cannot be
19 detected by the human eye, because humans primarily see differences.
20 Compensation is very problematic in areas, in particular, where non-adjacent
21 pixels are projected next to each other on the photosensitive material. In the IDSI
22 system, this affects the outer rows, because the exposed strips meet overlap
23 there.

24
25 In contrast to the IDSI system, individual image sections are exposed using the
26 digital screen imaging (DSI) system. The entire image is then composed of a
27 plurality of individual images. Attempts to transfer the system for compensating
28 non-uniformities used in the DSI system to adjust the energy in each cell
29 separately were not successful. On the one hand, the necessary transmission
30 rates at a maximum scrolling frequency of approximately 50 kHz and a
31 necessary gradation depth of a minimum of 6 bits—with 8 bits even better—and

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1 a light modulator width of 1024 cells far exceed the capabilities of control
2 electronics. On the other hand, a light modulator does not exist that would
3 operate quickly enough to guarantee a gradation of 6 to 8 bits at a cadence of 50
4 kHz.

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6 The object of the invention, therefore, is to present a device and a method with
7 which the exposure quality can be optimized using simple means.

8
9 The object on which the invention is based is attained by the fact that the device
10 comprises at least one device for varying the number of cells of the light
11 modulator used to expose the photosensitive material, or that, with the method
12 according to the invention, the number of cells of the light modulator used to
13 expose the photosensitive material can be varied.

14
15 The entire length of the image information is not scrolled through the light
16 modulator. Instead, the scrolling process is stopped after a certain, adjustable
17 number of cells. The exposure time can therefore be varied for every pixel in the
18 row on the photosensitive material to be exposed. The integrated energy of a row
19 can be defined exactly. The non-uniformities can thereby be compensated using
20 a simple means of control.

21
22 The great advantage of the device according to the invention over DSI devices is
23 that the number of cells to be calibrated can be reduced from many hundreds of
24 thousands of cells to approximately one thousand rows.

25
26 According to a further advantageous exemplary embodiment of the invention, the
27 light modulator comprises a digital mirror device (DMD). The individual mirrors of
28 the digital mirror device can be controlled well without serious problems. The
29 mirrors that are not used by the device according to the invention to expose the
30 photosensitive material direct the light beam imaged on it away from the
31 photosensitive material.

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1 According to an advantageous exemplary embodiment of the invention, the light
2 modulator comprises $1024 * 758$ cells. This allows the gradation of the exposure
3 energy to take place with a great level of detail. The adjustment can take place in
4 758 units or 1024 units, depending on the scrolling direction of the data pattern
5 by the light modulator.

6
7 According to another very advantageous exemplary embodiment of the invention,
8 it is provided that the light modulator comprises a liquid-crystal array, magneto-
9 optical cells, or ferroelectric cells. In principle, any other variation of light
10 modulators may be used as well. This results in the considerable advantage that
11 every existing IDSI device can be modified with a device for varying the number
12 of cells of the light modulator used to expose the photosensitive material.

13
14 As mentioned hereinabove, the object of the method is attained very
15 advantageously by the fact that the number of cells of the light modulator used to
16 expose the photosensitive material is varied.

17
18 The exposure time can be varied for every pixel on the photosensitive material to
19 be exposed, because the image information is no longer scrolled across the
20 entire length of the light modulator. The integrated energy of a row can be
21 defined very exactly. The non-uniformities can therefore be compensated using a
22 simple means of control.

23
24 According to a particularly advantageous exemplary embodiment of the method
25 according to the invention, it is not necessary to first transfer the image data to
26 the first column of the light modulator. The data can be transferred first to a
27 column lying further back, for example. The columns located before them are not
28 used for exposure. The exposure energy applied therefore decreases.

29
30 This is described in greater detail using the drawings, which represent an
31 exemplary embodiment of the invention.

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2 Figure 1 shows a schematic drawing of the entire exposure and modulation
3 device,

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5 Figures 2-5 show a schematic drawing of the principle of data pattern
6 transmission, and

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8 Figure 6 shows a schematic drawing of the light modulator with cells that are
9 used and not used for the imaging.

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11 Figure 1 is a schematic drawing of the exposure and modulation device 1: a light
12 source 2 is imaged on a light modulator 4 using a first lens 3. The position of the
13 photosensitive material 5 relative to the light modulator 4 is changed by a locator
14 6. The relative motion takes place in the direction of the cells of a row of the light
15 modulator. Data patterns are transferred to the first column with cells 8 of the
16 light modulator using a driver circuit 7. It is important that the transmission of the
17 data pattern be synchronized with the motion of the photosensitive material 5.
18 The data pattern transferred to the first column is moved to the next column in
19 synchronization with the relative motion, so that the data pattern transferred to
20 the photosensitive material 5 remains stationary on it. The light modulator 4
21 comprises a plurality of columns of cells 8. The data pattern transferred to the
22 light modulator 4 comprises combinations of activated and non-activated cells 8.
23 If the cells 8 are activated, the light falling on them is transferred to the
24 photosensitive material 5 via a second lens 9. The light that hits inactive cells is
25 directed away by the photosensitive material 5. A particularly positive aspect of
26 the exemplary embodiment shown is the fact that a device 10 is provided that
27 varies the number of cells available for exposure. This means that not all the
28 cells 8 in a row are available for transmission of the data pattern. Since the
29 intensity of exposure of the material to be exposed depends on the exposure
30 time, i.e., on the available cells 8, this device 10 makes it possible to compensate
31 non-uniformities in the image.

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Figures 2 through 5 illustrate how a data pattern is moved from cell to cell in a row while remaining stationary on the photosensitive material 5. In Figure 2, a signal reaches the first cell Z1. In Figure 3, the same data pattern is transferred to the next column—cell Z2 in this case—while a new pattern is transferred to the first column—cell Z1 in this case. In Figure 5, the data pattern input first has reached cell 4 (Z4). Cells Z5 through Z6 cannot be controlled by the device 10 for transmission of the data pattern. They are not available for exposing the photosensitive material. If a higher exposure intensity is required, they are activated and the data pattern is transferred further.

Figure 6 shows a light modulator 4 that is subdivided into rows R1 through R9 and columns S1 through S8. The cells 11 indicated by diagonal lines are available for exposure. Data patterns are input in column 8 and transferred to column S7. A different number of cells 11 can be controlled in the various rows R1 through R8. Since the intensity of exposure is integrated via the cells in a row, this results in different intensities of exposure for individual pixels on the photosensitive medium 5.

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